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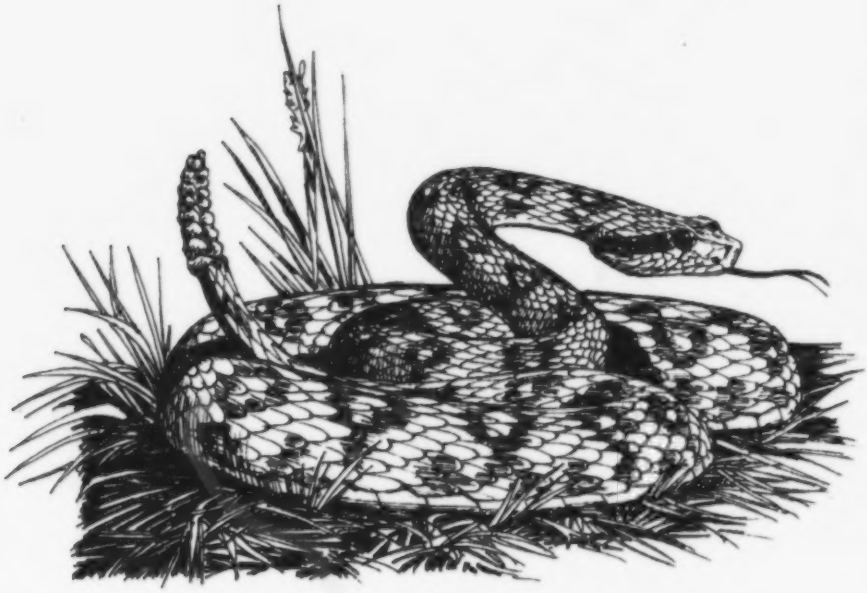
Rattlers and People: Conserving Rattlesnakes in Lethbridge



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SUSTAINABLE RESOURCE DEVELOPMENT

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Rattlers and People: Conserving Rattlesnakes in Lethbridge

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EXECUTIVE SUMMARY

A Lethbridge Rattlesnake Conservation Plan was developed in 2000 (Ernst 2000, 2002). It was initiated in response to ongoing losses of prairie rattlesnakes (*Crotalus viridis*) in Lethbridge. This report summarizes the results of the first five years of the Lethbridge Rattlesnake Conservation Program and provides recommendations for future conservation of rattlesnakes in Lethbridge.

Several of the conservation strategies in the Lethbridge Rattlesnake Conservation Plan have been completed, while others are ongoing. Emphasis has been placed on education of the public to reduce human/snake conflicts, and removal of problem rattlesnakes to more secure habitat away from urban development. In 2001, an artificial hibernaculum was constructed in Cottonwood Park. From 2001-2004, problem and vulnerable rattlesnakes captured in urban areas during the summer were translocated and maintained there until their release the following spring. In 2005, the response protocol was changed to translocate rattlesnakes to dens within their home range. This was done because recent studies have shown shorter distance translocations to be a more effective conservation strategy, and because rattlesnakes that had been translocated to Cottonwood Park were showing little fidelity to the artificial den.

All captured rattlesnakes were permanently marked using passive integrated transponder (PIT) tags and selected rattlesnakes have been equipped with a transmitter so that their activities can be monitored using radio telemetry. The movements of these rattlesnakes have been monitored to evaluate the effectiveness of the problem rattlesnake removal protocol, and to evaluate the survival rate of translocated rattlesnakes.

The current population of rattlesnakes in Lethbridge is estimated to be approximately 50 adults. Most Lethbridge rattlesnakes are resident in three areas: Popson Park, Cottonwood Park, and the "Bridge Site" (between Bridge Drive, Highway #3, and University Drive).

The future for Lethbridge rattlesnakes is uncertain due to loss of habitat from urban development, road kill mortalities, human persecution, disturbance, uncertainties regarding prey availability, and possible isolation from other populations. In the next five years there needs to be continuation of key rattlesnake conservation initiatives, including public education and awareness programs, quick response to problem rattlesnake calls, and ongoing evaluation of the effectiveness of rattlesnake response protocols. In addition, some important new conservation measures need to be initiated, including wildlife assessments prior to urban developments, provision of landscape buffers in rattlesnake habitat, adequate protection of areas around den sites, designation of rattlesnake movement corridors and installation of crossing structures, habitat acquisition, and initiation of studies to determine the long-term viability of the Lethbridge rattlesnake population.

Rattlesnake conservation in Lethbridge is a shared responsibility. The formation of a new Lethbridge Rattlesnake Management Coalition is recommended. This group will provide

a structure for conservation decisions and conflict resolution, as well as a means of accessing outside funds to enhance resources currently going towards rattlesnake conservation. Organizations invited to the management coalition would include City of Lethbridge (land manager), Alberta Fish and Wildlife Division (wildlife manager), researchers, as well as people and businesses potentially effected by rattlesnake management.

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Following is a list of the many people and organizations we would like to thank for their ongoing support of rattlesnake conservation in Lethbridge.

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- Helen Schuler Coulee Centre staff for their continued involvement in the public education program.

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- Citizens of Lethbridge for their continued support of the Lethbridge Rattlesnake Conservation Project.

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1 Introduction

Prior to the 1990's, little attention was paid to the Lethbridge population of prairie rattlesnakes (*Crotalus viridis viridis*). During that period, occasional complaints were made to Alberta Fish and Wildlife Division regarding rattlesnakes at the Popson Park picnic shelter or the newly developed Paradise Canyon subdivision and golf course. As the subdivisions of West Lethbridge grew and the Paradise Canyon golf resort became established, the Helen Schuler Coulee Centre (HSCC) began receiving reports of road-killed rattlesnakes, particularly on the Paradise Canyon road. The frequency of rattlesnake reports to Alberta Fish and Wildlife Division also increased.

Reports of human persecution of rattlesnakes and the increasing number of road kills prompted the City of Lethbridge ecosystem manager to initiate a study in 1997 to determine the distribution and location of rattlesnakes within the city. That led to discovery of one hibernaculum in Popson Park during the late summer of 1997 and two more hibernacula in 1998, one in Popson Park and one on private property in northwest Lethbridge (the "Bridge Site").

Ongoing road kills of rattlesnakes and human/rattlesnake conflicts led to a decision to develop a management plan in 2000 (Ernst 2000). Many of the conservation strategies outlined in that management plan were incorporated into the Lethbridge Rattlesnake Conservation Program (LRCP), which was developed in 2001 (Ernst 2002).

This report provides a five-year review of the Lethbridge Rattlesnake Conservation Program, summarizes current problems facing this urban rattlesnake population, and provides recommendations for future rattlesnake conservation in Lethbridge.

2 Annual Activities of the Conservation Program

2.1 1997-2000

Public education was the primary conservation emphasis during this period. Brochures and information sheets were distributed to residents of certain subdivisions and to the general public from the Alberta Fish and Wildlife Division office, the Lethbridge Public Library and Lethbridge City Hall. Some observational studies were also done during this period. In response to public complaints, Alberta Fish and Wildlife Division officers removed problem rattlesnakes from urban areas and translocated them, often releasing them outside the city. From 1997-2000, it is estimated that approximately 10 rattlesnakes a year were removed from Lethbridge through road kill mortalities, human persecution, and translocations.

2.2 2001

The LRCP was developed and implemented as a new approach to deal with "problem" rattlesnakes (those that come in conflict with people) and "vulnerable" rattlesnakes (those that are observed along roads and other areas where they are deemed vulnerable). An artificial hibernaculum with holding facilities was constructed in Cottonwood Park, a city

nature reserve on the extreme southwest corner of Lethbridge. A new translocation protocol was developed which involved translocating rattlesnakes to the Cottonwood Park artificial hibernaculum where they were contained by an enclosure fence. This was an effort to force them to hibernate at the artificial den, increasing the likelihood of their adopting Cottonwood Park as their new home range and of their returning to hibernate there in subsequent years. This served to provide a facility to use to gradually translocate rattlesnakes away from the intense urban development that was taking place in Lethbridge to a more secure and secluded habitat. Eighteen rattlesnakes were translocated to this site during the summer of 2001. They fed, mated, gave birth and successfully hibernated in the artificial den during the winter of 2001-2002 (Ernst 2002).

2.3 2002

Interpretive signs and brochure stations were installed in Popson and Cottonwood Parks. Passive Integrated Transponder (PIT) tags were implanted into 24 rattlesnakes, 9 of which had hibernated at the Cottonwood Park facility. Rattlesnakes contained at the Cottonwood Park facilities during the winter of 2001-2002 were released in May 2002. Radio transmitters were glued to the rattles of eight adults prior to release. Radio telemetry was done on the eight transmitter-equipped rattlesnakes until the transmitters detached in mid summer.

Data collected during early to mid summer indicated that the transmitter-equipped rattlesnakes selected east facing slopes in and near active Richardson's ground squirrel (*Spermophilus richardsonii)* burrows. Each transmitter-equipped rattlesnake used an area of less than 10 ha. Mating activity was observed on several occasions among these translocated rattlesnakes. Eighteen additional rattlesnakes were translocated to the Cottonwood Park facilities during the 2002 season (Ernst 2003). In 2002, the city purchased land adjoining Cottonwood Park, effectively doubling the size of the Nature Reserve.

2.4 2003

Eight rattlesnakes that had over-wintered at the Cottonwood Park facility were fitted with external transmitters and released. Only two of the transmitters stayed attached long enough to collect any meaningful data. Three of eight rattlesnakes released in the spring of 2003 were documented returning to the Cottonwood Park artificial den during the summer and fall of 2003. Twenty-three additional rattlesnakes were translocated to Cottonwood Park during the summer of 2003 (Ernst 2004).

2.5 2004

The rattlesnake containment fence surrounding the Cottonwood Park hibernaculum was removed in early spring 2004. Rattlesnakes at the site were released after being implanted with PIT tags. Two males were implanted with radio transmitters and three other males were equipped with external transmitters. During the 2004 season, 16 additional rattlesnakes were translocated to Cottonwood Park and released at the artificial den. In previous years almost all translocated rattlesnakes were from southwest Lethbridge but in 2004, six of the captured rattlesnakes had been removed from a residence in northwest Lethbridge. Eleven of the 16 translocated rattlesnakes were sub-adults. Because seven of

the rattlesnakes had been translocated very late in the fall, a decision was made to re-erect a containment fence to hold them at the Cottonwood Park hibernacula for the winter. There was no documentation of previously released rattlesnakes returning to the artificial den to hibernate in 2004 (Ernst 2004).

2.6 2005

A University of Lethbridge (U of L) graduate student's project was initiated in April 2005. The Masters student began investigating habitat use and movements of Lethbridge rattlesnakes through radio-tracking of snakes, mapping their movements, and describing habitat use. Eight mature males and one female were implanted with transmitters for radio telemetry. Forty rattlesnakes were PIT tagged in 2005. The graduate project will continue through the 2006 field season.

2.7 Summary 2001-2005

Since the program was initiated in 2001, a totoal of 62 rattlesnakes have been translocated to Cottonwood Park, and 98 rattlesnakes have been implanted with PIT tags. Thirty rattlesnakes have been tracked using radio telemetry (Table 1). During the same period there have been 18 reported deaths of rattlesnakes. During that time, there have been numerous reports of rattlesnake activity from homeowners and residents using natural areas in the city.

Table 1: Rattlesnakes handled, and known rattlesnake mortalities since 2001.

Year	Translocated to Cottonwood	PIT tagged	Telemetry	Deaths**
2001	14	0	0	7
2002	16	25	8	4
2003	15	10	8	2
2004	17	20	5	2
2005	0	43*	9*	3
Total	62	98	30	18

* Done as part of graduate program.

** Reported deaths only, actual mortality may be much higher.

3 Conservation Accomplishments

3.1 Education

One of the main objectives of the LRCP was to reduce human/rattlesnake conflict by educating the public (Ernst, 2003). This was based upon the premise that increasing the tolerance of humans towards rattlesnakes through education is crucial to conserving rattlesnakes (Nowak et al. 2002). The LRCP education program is ongoing and uses various methods including media, interpretive signs, educational brochures, posters, and presentations. Since 2001, the LRCP has been the subject of various articles in newspapers and magazines and shows on television and radio. Success is indicated by reduction in human persecution of rattlesnakes, increased reports of rattlesnake activity, and by a high level of citizen support for the LRCP.

3.2 Habitat development

One of the strategies proposed in the Lethbridge Rattlesnake Conservation Plan was to develop suitable denning areas in secure habitat within the city (Ernst, 2000). This was due to the concern that rattlesnakes denning in the Popson Park had an uncertain future because of planned urban development in southwest Lethbridge, as well as potential for further development of Popson Park.

Cottonwood Park was identified as the most secure area with suitable habitat features. It is designated as a Nature Reserve by the City of Lethbridge, and park use is restricted to pedestrians, with no dogs allowed. There is an abundant prey base (ground squirrels). Providing translocated rattlesnakes with secure habitat and suitable winter denning areas, was seen as a way to possibly establish a resident population in Cottonwood Park. There was an example of this occurring through the provision of an artificial den for timber rattlesnakes in New Jersey (Reinert 1993, Sealy 2002). In 2001 an "artificial" den was constructed in Cottonwood Park. Details of the site and construction were provided in Ernst (2002).

3.3 Establishment of Response Protocols and a Response Team

A volunteer corps was established in 2001 for response to problem rattlesnakes. This was done to enhance the role of Alberta Fish and Wildlife Division in responding quickly to rattlesnake calls from the public. A training session was delivered and some basic equipment was provided to people who could be expected to encounter rattlesnakes. Phone numbers of the response team were provided to the public in a brochure.

3.4 Translocation of Rattlesnakes

The translocation of 62 problem and vulnerable rattlesnakes from occurrence sites to Cottonwood Park was a significant accomplishment. Although every situation was unique, it is likely that very few of the individuals would have survived without this response action. While some snakes evidently either did not survive, or else emigrated out of the park, it is likely that about 25% of them are still resident there, and possible more.

3.5 Information on Behaviour, Movements, and Habitat Use

Considerable time has been spent monitoring rattlesnake movements, observing their behaviour, and documenting the habitat they are using. Summaries of this information are included in the next section of the report.

4 Current Knowledge on Rattlesnakes in Lethbridge

4.1 Distribution

Popson Park and Cottonwood Park in southwest Lethbridge, and the Bridge location in northwest Lethbridge, are the main areas of rattlesnake activity in Lethbridge (Appendix 1). There are occasional reports from Pavan Park in north Lethbridge and from the area near the Lethbridge Country Club in south Lethbridge. There are populations of rattlesnakes across the river from Cottonwood Park both on private land and in the Blood Reserve, as well as to the north of the city along both sides of the Oldman River.

Two dens in Popson Park have been monitored for the past several years. Observations in the spring of 2005 suggest that there may be additional small dens in Popson Park.

In Cottonwood Park there are two known natural dens in addition to the artificial den. They are small dens (likely <10 rattlesnakes in each) which some of the translocated rattlesnakes now occupy. Searches in Cottonwood Park have failed to reveal any additional dens. Prior to the LRCP being initiated, there was some rattlesnake activity in the Park, as reported by adjacent landowners. Also, occasional road-kills were recorded along the road between Popson Park and Cottonwood Park. It is uncertain, however, whether there was a resident population denning in Cottonwood Park prior to the LRCP or if the rattlesnakes were just using the park as summer foraging habitat.

The Bridge site is located in a triangle formed by University Drive, Highway 3, and Bridge Drive. In this area of northwest Lethbridge there is a den that may no longer be active, plus another newly discovered active den. During the early season of 2005, three adult males were captured there and other rattlesnakes were observed. A local resident also reported several rattlesnakes there in April 2005. There are anecdotal reports of rattlesnakes from users of an archery range in this area. The University of Lethbridge graduate student observed 10 rattlesnakes in the same general area in the late summer of 2005.

Various searches over the past several years have failed to reveal dens in the area of the Oldman River valley between Paradise Canyon and the Bridge site. As well, searches in Pavan Park, Alexander Wilderness Park, and the area in and adjacent to Six Mile Coulee have failed to reveal any dens on the east side of the river.

4.2 Rattlesnake Movements and Habitat Use

4.2.1 Popson Park

It is known from personal observations, reports, captures, and road kills that Popson Park rattlesnakes migrate in all directions from their dens. Since monitoring began in 1997, they have been observed on several occasions migrating between the "Rim" Den in Popson Park and the Paradise Canyon subdivision. Some of the Popson Park rattlesnakes move to the floodplain down slope from their dens, and there is evidence (based on road kills, reports, and removals) that some move towards the Cottonwood Park area.

Information from road-kills, personal observations, reports, and calls for removal since 1997, demonstrate that a substantial proportion of the Popson Park rattlesnakes traditionally migrated north into the Paradise Canyon subdivision, the adjoining golf course, and the area between Paradise Canyon and the University of Lethbridge. Much of this rattlesnake foraging habitat has now been eliminated by urban development. While there are still requests for removal of rattlesnakes from Paradise Canyon, over the past three years there have been no reports of road-kills on the Paradise Canyon Road or of rattlesnakes using the area north of the Paradise Canyon Road.

4.2.2 Bridge Site

Through road kills, telemetry, reports, and calls for relocation, it is known that rattlesnakes use the upland areas to the west as well as the floodplain to the north and south of the Bridge site. Rattlesnake habitat in northwest Lethbridge is being lost through residential development along the western boundary of the Bridge site while areas north and south of the site are already developed.

Movement patterns for the Bridge group of rattlesnakes are less clear, but observations, reports, relocations, and road kills all show that they cross the road to the south and they migrate upslope to the west. In 2004, six rattlesnakes were translocated from an acreage bordering the west side of the Bridge site. Road kills have been observed as far west as University Drive and rattlesnakes have been translocated from the Rogers tower site to the northwest of the Bridge site as well as from Bridge RV park to the north.

4.2.3 University of Lethbridge

Rattlesnakes are occasionally reported and translocated from the grounds of the University of Lethbridge. The origin of these rattlesnakes is unknown. The university area was searched for dens but none were found. The snakes may have migrated from the Bridge site (to the north) or from Popson Park (to the south) or perhaps both. To date, none of the radio-tagged rattlesnakes have moved to the University grounds.

4.2.4 East of Oldman River

Reports from east of the river are rare, but in recent years two rattlesnakes have been translocated from the Lethbridge Country Club. Three rattlesnakes were reported there in 2005. It seems most likely that these snakes would have migrated from the south, but they also may have crossed from the west side of the river. Given that there is a high amount of urban development to the north, it is less likely they came from that direction.

4.2.5 Cottonwood Park

Cottonwood Park rattlesnakes migrate onto private land west and east of the park. It is unknown whether they interact with rattlesnakes across the Oldman River from the park. One Popson Park male rattlesnake released in Cottonwood Park in 2002 returned to the Popson Park rim hibernaculum where he was observed in April 2005. In 2004, two male rattlesnakes released in Cottonwood Park were captured at an acreage bordering the west edge of Popson Park. There have been three confirmed road-killed rattlesnakes on the Cottonwood Park road since 2003.

4.3 Reproduction and Recruitment

4.3.1 Production

Since 1998, there have been 15 clutches of neonates observed in Popson Park. Five clutches have been observed in Cottonwood Park since 2001. Burrows within the den complex as well as areas well away from known dens are used as rookeries. In summers with normal weather, neonates are born around September 1, but in 2002 neonates were not observed until early to mid October. It was likely the exceptionally cloudy and wet summer that resulted in the late births. Gravid females may require higher than normal body temperatures to accelerate pregnancy and develop young (Goode and Duvall, 1989).

Reinert (1993) suggested that reproductive success is related to body temperature making thermal conditions one of the most important factors in habitat selection. Furthermore, Martin (2002) states that in his study reproductive failures were due to weather.

4.3.2 Survival of Neonates

The rate of neonate survival in Lethbridge is unknown, but is likely very low. Weather patterns in any given year may seriously impact reproductive success for that year. In 2002, there was no known neonate survival, likely because the young were born very late in the season (October) in contrast to most years when birthing takes place around September 1. Solar energy may be more important than ambient temperature because rattlesnakes are very efficient at raising their body temperature by sun basking even when temperatures are far below optimum. Rattlesnakes in Lethbridge have been observed sun basking when temperatures were just 9^{0}C.

4.3.3 Age Classes of Lethbridge Rattlesnakes

Observations at Popson Park dens during April 2005, suggest that a sub-adult age class (estimated to be < 5 years old) is dominating the Popson Park group of rattlesnakes. This is likely a result of the removal of many adult rattlesnakes from the Popson Park/Paradise Canyon area since the LRCP was initiated in 2001. Twelve of the 18 rattlesnakes captured and PIT tagged in the Popson Park/Paradise Canyon area in the spring and early summer of 2005 were sub-adult or juvenile. The estimate of age class was based on length and taper of rattle and the size of the rattlesnake. Gannon and Secoy (1984) suggest that rattlesnakes > 80 cm SVL and 2+ years old are adults and sexually mature, but with slower growth of rattlesnakes in the Lethbridge population it likely takes five years for a snake to grow to this size. The growth categories used in a Grasslands National Park study are probably more applicable to Lethbidge (Kissner et al 1996). Those age classes are: neonates (~400-500 mm); subadults, (~500-700 mm); and adults, (~700-1300 mm).

The disproportionate number of sub-adults in the Popson Park group of rattlesnakes may result in reduced reproduction over the next 2 to 3 years. It is possible, however, that age estimates used may be inaccurate, or that there are additional adults present, but not observed. The University of Lethbridge graduate student has reported some additional adult rattlesnakes in Popson Park. Checks in the areas of the dens during emergence in 2006 may help to confirm presence or absence of adult snakes.

4.3.4 Age of Maturity

MaCartney et al. (1990) showed that a small male (SVL 535 mm) had mature sperm, but the courtship and mating activities that have been witnessed six times in Lethbridge have only involved mature adults. Young male rattlesnakes may be physically capable of mating, but likely don't because of competition from mature males. Sealy (2002) in his study of timber rattlesnakes, estimated the youngest reproductive females were seven years old, while MaCartney et al. (1990) found that many mature females did not produce young until they were 700-760 mm SVL. In his study of timber rattlesnakes, Martin (2002) stated that reproduction typically occurs in both males and females 10 years or older. Most studies suggest that reproductive age would be at least five years for males.

and at least seven years for females. Female rattlesnakes generally have a biennial or greater breeding cycle and neonate survival is low (Graves and Duvall, 1993; Gannon and Secoy, 1984).

4.3.5 Influence of Body Condition on Reproductive success

Reduced summer habitat may also suppress reproductive success in the Popson Park rattlesnakes. Ground squirrel populations are limited in Popson Park, and there is no information on the distribution and abundance of alternate prey species. Based on body condition estimates of captured rattlesnakes during the spring and early summer of 2005, the Popson Park rattlesnakes had lower fat reserves than rattlesnakes from Cottonwood Park or from the Bridge site. Females need to have stored fat reserves in order to successfully reproduce (Sealy, 2002).

At the Bridge Site, 13 of the 15 rattlesnakes handled during the spring and early summer of 2005 were adults with good to excellent body condition. This suggests that rattlesnakes at the Bridge site will have good reproductive success in future. Anecdotal reports from users of the archery range suggest the Bridge Site population may have increased over the past five years.

4.4 Estimate of Rattlesnake Population Size

The current population of adult rattlesnakes in Lethbridge is estimated to be approximately 50. This was derived from observations at the known dens in the City. A summary of information known for each site follows.

4.4.1 Popson Park

Monitoring of known hibernacula was done in spring and fall of each year to estimate the population. The highest number observed at the "rim den" in Popson Park was 23, seen in 2002, while as many as 10 have been seen at the "slope den."

4.4.2 Bridge Site

In 2002 less than 10 rattlesnakes observed at the Bridge Site den. The observations in 2005 suggest the population is higher than this.

4.4.3 Cottonwood Park

From 2001 to 2004, sixty two "problem" rattlesnakes were translocated to Cottonwood Park from various parts of Lethbridge. For the first three winters they were forced, by a fence-proof enclosure, to use the artificial hibernaculum. This was done as an effort to increase their fidelity towards the site. The snake enclosure fence was removed in the spring of 2004. In 2005 there were no rattlesnakes observed at the artificial den site. However, there were 15 adult rattlesnakes observed using two newly discovered natural dens in the park in 2005. Eight of the snakes were scanned for PIT tags and it was determined that they were all from the 62 rattlesnakes that were released in Cottonwood Park since 2001. Five of the snakes were not scanned for PIT tags, and two non-tagged snakes were found. Of the original 62 translocated rattlesnakes there were 5 documented deaths (4 at the den and 1 road kill) and 3 outward migrations towards Popson Park. Using an annual adult mortality rate of 20% as estimated in a study on Western

diamondback rattlesnakes (Nowak et al., 2002), and assuming no immigration or recruitment, there should be a population of about 30 rattlesnakes resident in Cottonwood Park (Table 2).

Table 2: Cottonwood Park population model.

Year	Translocated	Translocated + Carryover	Mortality	Calculation	Population Carryover
2001	14	0	2.8	14 x .80	11.2
2002	16	11.2	5.44	27.2 x .80	21.76
2003	15	21.76	7.35	36.76 x .80	29.40
2004	17	29.40	9.28	46.40 x .80	37.12
2005	None	37.12	7.42	37.12 x .80	29.69

Due to the difficulty of gaining an accurate census through snake counts at den entrances, it is possible that the population estimate of 15 is conservative. However, it is likely that the Cottonwood Park population is lower than modelled in Table 3. It is likely that both emigration and mortality were higher than documented. Also, some rattlesnakes may be congregating at additional unknown dens in Cottonwood Park.

Of the eight snakes known to originate from translocations, five were adult females. Having a core group of adult females in Cottonwood Park will be beneficial in providing a nucleus for a resident population. One clutch of neonates was born in Cottonwood Park in 2005 and another six clutches were observed there in previous years. The presence of two "new" adult rattlesnakes (one male and one large female) captured and PIT tagged in Cottonwood Park in 2005 indicates that there is either a resident population or immigration occurring from other areas.

5 Threats to the Lethbridge population of rattlesnakes

The LRCP project area is on the western limit of prairie rattlesnake range in North America. Payne and Bryant (1994) stated that populations with limited or patchy distribution, poor dispersal ability, low reproductive ability, and which are dependent on threatened habitats are at greater risk of extirpation. Martin (2002) states that species on the periphery of their range may be more vulnerable to extirpation from factors such as weather and human predation. These situations are directly applicable to the Lethbridge rattlesnake population. Specific threats include:

- Increased urban development resulting in loss of habitat;
- Increased development of roads and more vehicle traffic resulting in rattlesnake mortality;
- Increased human population and increased recreational use of rattlesnake habitat resulting in higher likelihood of human/rattlesnake conflicts;
- Direct persecution;
- Marginal climate due to being at the periphery of the continental range;
- Natural predation;
- Limited prey availability

5.1 Loss of Habitat due to Urban Development

Prior to the U of L opening in West Lethbridge about 25 years ago, contiguous and available rattlesnake habitat stretched from Popson Park to Highway 3. Over the past 15 years, about 75% of the rattlesnake habitat in southwest Lethbridge has been directly lost to urban development. Intensive urban development, particularly since the early 1990's, has resulted in habitat becoming isolated into small patches. The Paradise Canyon subdivision and golf course was developed in the early 1990s in an important migration route to summer foraging habitat for the Popson Park rattlesnakes. The foraging habitat was a large city-owned overgrazed pasture of 30-40 hectares, which provided upland habitat adjacent to a large area of coulee and river valley habitat. This combined area provided a large area of relatively undisturbed summer habitat (Figure 1). A substantial number of rattlesnakes from Popson Park used this habitat as evidenced by their observed crossing the Paradise Canyon Road during spring and fall migrations.

Development began in the Riverstone subdivision in 2000. That subdivision has removed most of the remaining upland habitat to the north of Popson Park. An earlier subdivision, Mountain View Heights, located west of Riverstone, had already removed much of the rattlesnake habitat west of Popson Park. Cumulatively, these recently developed subdivisions have eliminated much of the foraging habitat for the Popson Park rattlesnakes (Figure 2). The resulting habitat is fragmented by residential developments and roads.

The Bridge site currently provides suitable habitat for rattlesnakes that stay within the area, but a sale and proposed development of the area could result in habitat loss and an unacceptable level of conflict.

Much of the remaining rattlesnake habitat in southwest Lethbridge is in Popson and Cottonwood Parks. The Popson Park habitat is jeopardized by a large portion of it being designated as an off-leash dog area. The park also includes a group camping area and picnic shelter, and has a road through it. City zoning of the park allows for future recreational development.

5.2 Rattlesnake Mortality due to Roads

During the late 1990's there were several rattlesnakes killed on the Paradise Canyon road every year. In northwest Lethbridge, rattlesnake habitat is limited to a triangle of recreation land (Bridge Site) surrounded by busy roads and newly developed acreages (Figure 3). In order for rattlesnakes to migrate out of this area, they would have to cross a busy road and/or migrate into a developed area. Road kills along Bridge and University Drive have been reported in most years.

5.3 Disturbance factors

Reproductive success may be highly dependent on gravid females being able to maintain appropriate body temperatures. Graves and Duvall (1993) observed that gravid female prairie rattlesnakes maintained higher body temperatures than other prairie rattlesnakes and that even small differences in body temperature could have significant effects on offspring viability. Recent studies suggest that direct human disturbance of these snakes

is detrimental to them. Timber rattlesnakes captured at a site had a tendency to avoid that site in the future and a gravid female altered her use of a gestation site because of human intrusion (Sealy 2002).

Frequent visits to a rookery can cause gravid females to seek security cover underground thus reducing the amount of time they are able to maintain optimum body temperatures for reproduction. Appropriate basking sites, kept free of disturbance, are required for all snakes because their main biophysical requirement is the ability to raise and maintain an optimum body temperature (Dodd, 1993). The Lethbridge population experiences direct human disturbance from a number of factors including random encounters with people, more frequent human encounters in recreation areas, and capture and direct handling during research and management activities. Locations where rattlesnakes are frequently encountered by people include the Cottonwood Park trail to the floodplain, the archery range at the Bridge Site, and Human/dog/rattlesnake encounters at the Popson Park dog off-leash area. Frequent disturbance of this nature can affect reproduction, growth, and survival of rattlesnakes (Sealy, 2002).

Although care has been taken to minimize disturbance during research and management activities at rattlesnake dens, it is possible that these disturbances have had an impact on the population, resulting in avoidance of the frequently disturbed areas by some snakes. It is possible that the lack of fidelity of the translocated rattlesnakes towards the Cottonwood Park artificial den is related to the high level of human activity that took place there from 2001 to 2004. Anecdotal observations from a major rattlesnake study on Canadian Forces Base Suffield indicated that there were fewer rattlesnakes using two den sites following disturbance at those dens (J. Wright, pers. comm.).

5.3.1.1 Radio-telemetry

Radio telemetry is a valuable tool that is commonly used to study snakes, but Weatherhead and Blouin-Demers (2004) found that implanting black ratsnakes with transmitters resulted in a significant loss in annual mass gain. They also found that the clutch mass was significantly lower, and survival may have been adversely affected. They speculated that the negative effects may have been because of impaired behaviour, energy cost of transporting the transmitters, infection from the surgery, and increased disturbance by researchers. Trials using external glue-on transmitters in the Lethbridge Rattlesnake Conservation Program were unsuccessful, due to transmitters being snagged vegetation or objects, and rattle segments breaking off. Therefore, internal implants of transmitters have been used in Lethbridge, with no known direct impacts on the snakes. The use of internal implant transmitters has been reviewed and approved by the Alberta Fish and Wildlife Animal Care Committee. The protocol used has transmitters being implanted primarily in adult male rattlesnakes. This protocol should continue to be adhered to, and applied only to translocated rattlesnakes and those that are part of well-planned research studies covered by an Alberta Fish and Wildlife Research Permit.

5.3.1.2 PIT tags

Studies of rattlesnakes require permanent marking because it is necessary to identify individuals. Before PIT tags were developed, scale clipping was a common method of

permanently marking rattlesnakes. The major disadvantages of scale clipping compared to PIT tagging is that more handling is required to do the clipping and recapturing and, upon recapture, restraining and examining the snake is necessary to identify it. Identification of a PIT tagged snake involved simply waving the PIT tag reader over the area of the snakes body where the PIT tag was implanted. In their study of pigmy rattlesnakes (*Sistrurus miliarius).* Jemison et al. (1995) concluded that PIT tagging was a preferred method of marking snakes because there was no demonstrable impact on growth or movement. Reading PIT tags can disturb a rattlesnake for a short period of time, but is far less invasive than other forms of marking and identification. Since the LRCP was initiated in 2001, 98 rattlesnakes have been permanently identified with PIT tags. Although a brief period of disturbance is experienced by the snake, the conservation benefits of PIT tagging warrant it's continued use in the Lethbridge Rattlesnake Conservation Program.

5.4 Prey Availability

Popson Park appears to have a limited prey base. Richardson's ground squirrels are present in the south end of the park near the picnic shelter. A ground squirrel reintroduction was done in the north end of the park in 1998, but they never became established. It is possible that some element of the habitat (eg. Soil type) is unsuitable for ground squirrels. Abundance and diversity of other prey in Popson Park is unknown. The fact that body condition of Popson Park rattlesnakes during the spring of 2005 was inferior to that of rattlesnakes captured in other parts of the city, suggest that there may be an inadequate prey base for rattlesnakes in Popson Park. There is a large population of Richardson's ground squirrels on the grounds of the University of Lethbridge, however, There is likely little access to that prey base due to habitat fragmentation causing barriers to rattlesnake movement.

There is a large, widely distributed population of Richardson's ground squirrels in Cottonwood Park. Deer mice (*Peromyscus maniculatus)* and voles (*Microtus spp.)* have been observed in Cottonwood Park as well, but it is not known how abundant they are. Body condition of rattlesnakes captured in Cottonwood Park was very good to excellent.

There does not appear to a ground squirrel population at the Bridge location, but there are piles of rubble and trash scattered around the site, likely providing habitat for other rodents.

5.5 Natural predation

In addition to all of the problems associated with surviving in an urban environment, rattlesnakes face a similar suite of predators as they would if they were in a natural non-urban environment. Predators include coyotes, foxes, badgers, skunks, and various raptors. Neonates and juveniles are potential prey for other species including crows, magpies, and weasels. Neonates are particularly vulnerable. It is not known how many rattlesnakes are lost to predators each year in Lethbridge.

5.6 Climate change

Most information on how climate change will affect the prairies suggests that there will be an increase in temperature and a decrease in soil moisture. A rise in temperature with a corresponding increase in sunlight could benefit the Lethbridge population of rattlesnakes through higher growth and reproductive rates. It could also contribute to a westward range expansion up the Oldman River valley. If climate change was to result in higher precipitation and less sunshine, then rattlesnake growth and reproduction rates could be negatively impacted.

6 Management Recommendations

6.1 Wildlife Assessment of New Developments

New proposed transportation, residential and commercial developments in Lethbridge rattlesnake habitat need to have pre-development wildlife assessments done to determine wildlife concerns requiring consideration in the development planning process. The wildlife assessments should include wildlife surveys, carried out by qualified biologists using Alberta Fish and Wildlife inventory protocols, or other acceptable techniques. They should also include an evaluation of landscape suitability for rattlesnakes and other species, review of existing wildlife data (eg. FWMIS-Fish and Wildlife Management Information System; ANHIC-Alberta Natural Heritage Information Centre), and discussions with wildlife researchers, and residents.

At the time of preparation of this report there is a pending commercial development in the Bridge Site. If this development goes ahead, a strategy for conservation of the resident rattlesnakes will need to be developed as part of the pre-development wildlife assessment.

Also, at this time there is pre-planning being done towards identification of a preferred route for a major highway by-pass around Lethbridge (Crowsnest Highway #3 to the International Trade Highway #4). A Wildlife Assessment, incorporating rattlesnake conservation, needs to be done at an early stage of planning for this large project.

Similarly, it is recommended that wildlife assessments be done of areas under consideration for new residential developments, and associated infrastructure. Early identification of rattlesnake conservation values (and other wildlife values), can allow for appropriate planning of these areas, resulting in better wildlife conservation, and reduction of the potential for future negative interactions between Lethbridge residents and wildlife.

This practice would allow for identification of potential issues, and exploration of the best ways to mitigate impacts. Early consideration of wildlife impacts not only provides greater opportunity to mitigate impacts, but also results in less financial cost to the developer than situations where exploration of the wildlife issues is done at a later stage. Mitigation of impacts may include identification of key habitats, establishment of reserve areas in those key habitats, designation of setbacks, providing buffer zones between key habitats and urban developments, identification of corridors, construction of crossing

structures, fencing, and possible other measures. The Alberta Fish and Wildlife Sensitive Species Guidelines recommend a 200 metre setback between developments and rattlesnake dens, such as the Popson Park dens.

6.2 Establishment of Landscape "Buffer" Zones

Protected landscape buffer zones (a minimum of 50 m wide) should be provided between new urban development and the coulee breaks and other natural areas in Lethbridge. Existing buffer zones should be protected and enhanced whenever possible. Native vegetation should be provided on all protected areas and fencing may be strategically located to prevent rattlesnakes and other wildlife from entering subdivisions. The Alberta Fish and Wildlife Sensitive Species Guidelines recommend a 200metre setback between developments and rattlesnake dens, such as the Popson Park dens. This setback should be provided for through establishment of landscape "Buffer Zones" of this size around known dens in Popson Park, the Bridge Site, and Cottonwood Park. In situations where there are already developments within the buffer zones, then a site specific evaluation should be carried out to determine an appropriate management strategy for that site. Individual habitat management plans should be developed for landscape buffer zones, as well as other rattlesnake habitat areas and movement corridors.

6.3 Habitat Acquisition, Securement, and Protection

Rattlesnake habitat in Lethbridge has been directly lost and severely impacted by urban development. Rattlesnakes face ongoing threats on roads, in recreation areas, and in residential yards. Some of these problems and threats can be mitigated by protecting existing habitat and by providing more secure habitat through land purchases and other conservation measures. It may also be possible to allow passage of rattlesnakes through urban movement barriers by pre-planning, or "retrofitting" suitable movement structures and corridors.

There is an immediate need to increase the amount of secure habitat available to the Popson Park rattlesnakes. Popson Park should be expanded by purchase and protection of a strip of land bordering the western edge of the park. This includes an existing strip of native prairie as well as some cultivated land (20 to 30 ha). Restoration of native grassland in the cultivated portion is recommended to improve rattlesnake habitat. The resulting landscape buffer should be designed to provide a minimum 200 metre setback between residential development areas and the rattlesnake dens in Popson Park. This need can possibly be incorporated into setbacks already being determined based on slope stability. This would further help to decrease the likelihood of increased ground water seepage from the new residential neighbourhood increasing the problem of unstable coulees. Maintenance of this landscape buffer zone in native grassland would eliminate the need for supplemental water, thereby helping to control coulee slumping. Suitable fencing along the setback boundary would prevent wildlife, including rattlesnakes, from entering the adjacent residential areas.

In addition to current City zoning, a conservation partner should be engaged to place a protective Conservation Easement on the land title of Cottonwood Park. This will help to ensure that future City administrations continue the protection currently in place for

Cottonwood Park. In addition to long-term rattlesnake conservation, this would also provide protection for the important representative cottonwood stands and at least 3 rare plant species that occur there. When land adjacent to Cottonwood Park becomes available, it should be purchased and incorporated into the park to increase the size of this important prairie/floodplain park. This would benefit all wildlife species in the area, and provide a valuable future investment for Lethbridge residents.

6.4 Establishment of Habitat linkages

Much of the Paradise Canyon coulee habitat is no longer available to rattlesnakes because of the busy Paradise Canyon Road. Road mortality of rattlesnakes could be reduced through provision of under-road passages between habitats (Dodd, 1993). A linking corridor is needed to allow rattlesnakes to migrate between Popson Park and remaining coulees and meadows to the north of the Paradise Canyon subdivision. Drift fencing could be used to direct migrating rattlesnakes to under-the-road culverts. Such an arrangement would provide Lethbridge rattlesnakes with a safer and more effective migration corridor. Corridors of this nature can be used to link fragmented habitat patches, thereby reducing the possibility of extirpation (Payne and Bryant, 1994).

Similarly, a corridor linking Popson Park with Cottonwood Park is needed to enhance the viability of the Lethbridge population of rattlesnakes. Road mortality and calls from landowners indicate that rattlesnakes are using the road as a migration corridor. Rattlesnake passage structures may be possible here as well, although difficult terrain features and existing residential acreages in the area may provide challenges.

6.5 Management of Recreation in Rattlesnake Habitat

The Popson Park dog off-leash area is a high human/rattlesnake conflict area. The dog off-leash area should be re-designated as a seasonal use area, available only during the period October 15 to April 15, when rattlesnakes remain in the den areas. This would reduce the likelihood of rattlesnake/people/dog encounters in that area of important rattlesnake habitat. This initiative would result in increased security of rattlesnake habitat, and improved safety for park users and their pets.

It is also recommended that the zoning and future development plans for Popson Park be reviewed, with a goal of maintaining it as a semi-natural park, rather than developing it into an intensive recreational use area. Future development within the valley of the Oldman River, including development of recreational parks, should be minimized. Parks for intensive recreational use should be developed in upland areas, which generally are not as important habitat for rattlesnakes and other wildlife.

6.6 Responses to Complaints Regarding Rattlesnakes

Due to the limited capability of Alberta Fish and Wildlife Division to respond to all calls regarding rattlesnakes in a timely fashion, the rattlesnake response corps should be continued. The list of phone numbers should be updated in the brochure provided to Lethbridge residents in rattlesnake habitat areas. Another training course should be provided for corps members as well as City workers, golf course groundskeepers, and others who are more likely to encounter rattlesnakes.

6.7 Translocations

Since initiation of the LRCP, most problem rattlesnakes were translocated to Cottonwood Park, which was generally more than 1 km from point of capture. This was justified by the desire to remove the rattlesnake from the site of the problem, and to populate the suitable habitat in Cottonwood Park. Recent studies have shown that relocating rattlesnakes more than 400m from the point of capture is detrimental to them, and that mortality rates of long distance translocations are high compared to resident snakes (Hare, 1999; Nowak et al., 2002; Sealy, 2002). The advantage of the long distance translocations to Cottonwood Park was that the rattlesnake would be moved to more secure habitat where it may be able to adapt to its new environment. This rationale was supported by Reinert (1993) who observed that timber rattlesnakes translocated into distant populations were capable of locating communal hibernacula perhaps by trailing resident snakes. However, other studies showed lower success of long distance translocations due to high mortality rates (Nowak et al., 2002; Sealy, 2002). It is also possible for long-distance translocations to impact reproduction by removing too many breeding age rattlesnakes from a population.

Sealy (2002) found that short distance translocations allowed for 100% survival of the rattlesnakes in his study. He defined short distance translocations as less than 200m. In Lethbridge, some city residents might not be willing to tolerate such an approach adjacent to residential subdivisions because of the higher risk of the rattlesnake returning. Switching to short-distance translocations may therefore increase the risk of people illegally killing rattlesnakes. In 2005 the Lethbridge rattlesnake response protocol was modified to translocate captured rattlesnakes to the closest known den, likely within the seasonal home range of the individual snake. In most cases, this distance was less than 500 m. This was a suitable compromise between the benefits and liabilities of short and long distance translocations. It effectively reduces both the risk of the rattlesnake re-offending and the risk of it not finding a suitable winter hibernaculum. This rattlesnake response protocol will be continued. It will involve site-specific decisions for each vulnerable or problem rattlesnake occurrence, but decisions would be based upon the desire to retain rattlesnakes within their home ranges. In most cases, rattlesnakes which must be removed from an area, will be translocated to the nearest active den.

6.8 Education and Awareness

Education programs should be continued and enhanced to ensure all Lethbridge residents are aware of rattlesnake conservation initiatives in Lethbridge. Dodd (1993) suggests that snake communities will vanish if there is a long delay in gaining public support through effective conservation messages. The brochures and the Lethbridge Rattlesnake Poster display should be updated.

Warning signs should be maintained in recreational areas that are in rattlesnake habitat. Road signage should be reviewed and updated where necessary. Specifically, the large Rattlesnake Road sign between Riverstone and Paradise Canyon subdivisions, removed during new construction in 2005, should be erected again in a new location. It is

suggested that this location should be just south of the new traffic "Roundabout" in that area.

6.9 Long-term Population Viability

Due to the small size of the population, the possibility of it being an isolated population, ongoing habitat loss, and disturbance, there is uncertainty regarding the long-term viability of the Lethbridge rattlesnake population. Studies are needed to determine the degree of connectivity between the Lethbridge population of rattlesnakes, and those in surrounding areas. It would also be helpful to understand more about prey availability through studies of the abundance and distribution of prey species in Rattlesnake habitats.

7 Research needs

7.1 Rattlesnake Movements and Habitat Use

Over the past several years, considerable effort has been devoted towards work to determine the abundance, distribution, movements, and behaviour of the Lethbridge population of rattlesnakes. The current University of Lethbridge graduate project will further improve the knowledge on habitat use and movements of the Lethbridge rattlesnake population. Following this study, efforts need to be concentrated on rattlesnake populations surrounding Lethbridge, in order to better understand their habitat use and movements, and the degree of interaction between those rattlesnakes and the urban rattlesnake population.

7.2 Population Size and Connectivity

There is considerable theoretical literature about what comprises a minimum viable wildlife population, but little solid information. Determining the population viability of snake species is hard because they are difficult to study in the field (Dodd, 1993). However, prior to being able to understand whether the Lethbridge rattlesnake population is large enough for long-term sustainability, it is necessary to know the degree of isolation of the population. If there is some degree of connectivity between the local snakes and the rattlesnakes in the surrounding rural area, then the chance of long-term sustainability is much higher than if the Lethbridge rattlesnakes are now isolated due to urban development. Studies should be designed to determine the degree of connectivity between the Lethbridge rattlesnake population and those of surrounding areas.

7.3 Habitat improvement

Some natural processes no longer occur in urban rattlesnake habitat, such as large herbivore grazing, and frequent fires. This has resulted in changes in the vegetation which may alter habitat for rattlesnake prey species such as small mammals and birds, which in turn effect species dependent on them (Dodd, 1993). Ways to improve the quality and quantity of wildlife habitat need to be explored, including considering restoring or emulating some natural processes to natural areas in Lethbridge. Conservation programs require natural habitat to succeed (Dodd, 1993). Measures to enhance certain areas to encourage rattlesnake use, and to dissuade use of other areas need to be researched. For example, it may be possible to provide suitable habitat conditions for prey, and placement of cover structures, to encourage rattlesnake use of a

natural area adjacent to a residential area. Similarly, maintenance of residential areas in conditions less suitable for rattlesnakes could help to reduce human/rattlesnake conflicts.

7.4 Quantification of Habitat and Prey Base

Lethbridge has an extended network of natural areas associated with the Oldman River valley. It would be beneficial to determine how much of this area provides secure habitat for rattlesnakes. It would also be useful to understand the abundance, and distribution of various prey species. This information would be useful for future wildlife management decisions. Estimating the size of existing habitat could be done through Geographical Information Systems (GIS) technology. Prey species and abundance information could be gained through a well-designed small mammal study. Encouragement should be provided to the University of Lethbridge to pursue research work of this type.

8 Lethbridge Rattlesnake Management Coalition

Rattlesnake conservation in Lethbridge is a shared responsibility. The formation of a new Lethbridge Rattlesnake Management Coalition is recommended. This group could provide a structure for conservation decisions and conflict resolution, and could also provide a means of accessing outside funds to enhance resources currently going towards rattlesnake conservation. Organizations which should be invited to participate in the rattlesnake management coalition include: City of Lethbridge (land manager), Alberta Fish and Wildlife Division (wildlife manager), researchers, as well as people and businesses potentially effected by rattlesnake management.

9 Conclusion

The Lethbridge Rattlesnake Conservation Program has been underway for five years. The information available for conservation of rattlesnakes in the city has been enhanced. Several innovations for rattlesnake management have been attempted, with varying degrees of success. The LRCP has resulted in considerable new information becoming available, resulting in the recommendations for future management detailed in this report. There is also a need for ongoing research to further improve knowledge.

The future for Lethbridge rattlesnakes is uncertain due to loss of habitat from urban development, road kill mortalities, human persecution, disturbance, uncertainties regarding prey availability, and possible isolation from other populations. In the next five years there needs to be continuation of key rattlesnake conservation initiatives, including public education and awareness programs, quick response to problem rattlesnake calls, and ongoing evaluation of the effectiveness of rattlesnake response protocols. In addition, some important new conservation measures need to be initiated, including: wildlife assessments prior to urban developments, provision of landscape buffers in rattlesnake habitat, adequate protection of areas around den sites, designation of rattlesnake movement corridors and installation of crossing structures, habitat acquisition, and initiation of studies to determine the long-term viability of the Lethbridge rattlesnake population.

This document was prepared primarily for use by City planners and managers, wildlife managers, urban developers, and Lethbridge residents. However, it will be of interest to anybody involved in rattlesnake conservation or research. Lethbridge is a unique city with a diversity of natural areas. Lethbridge residents need to work together to sustain the small population of prairie rattlesnakes in Lethbridge. This will not only benefit this single species, for the rattlesnake is an indicator of ecosystem health. If the natural landscape is good enough for rattlesnakes, it will also support many other native species of plants and wildlife. The provision of an intact natural ecosystem, within the boundaries of an urban centre, would be a special benefit for all who live in Lethbridge.

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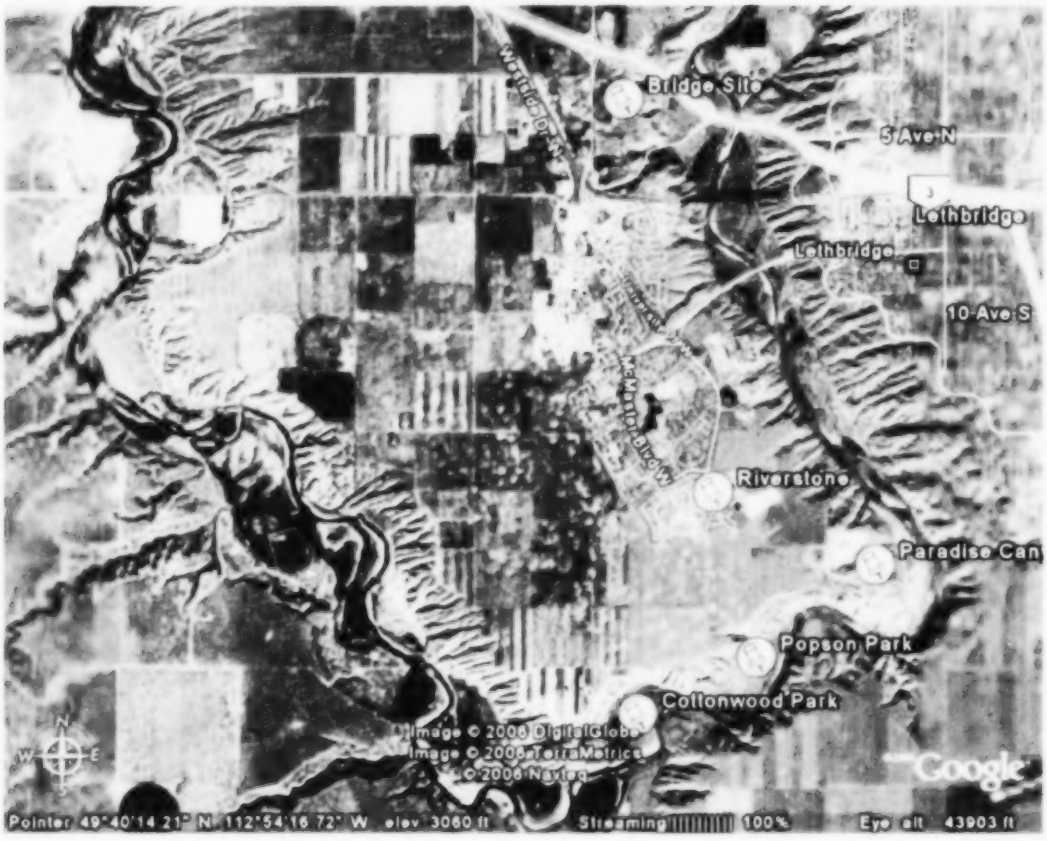
11 Appendix 1: Map of West Lethbridge



11 Appendix 1: Map of West Lethbridge

12 List of Titles in This Series

(as of April 2006)

No. 1 Alberta species at risk program and projects 2000-2001, by Alberta Sustainable Resource Development, Fish and Wildlife Division. (2001)

No. 2 Survey of the peregrine falcon (*Falco peregrinus anatum*) in Alberta, by R. Corrigan. (2001)

No. 3 Distribution and relative abundance of the shortjaw cisco (*Coregonus zenithicus*) in Alberta, by M. Steinhilber and L. Rhude. (2001)

No. 4 Survey of the bats of central and northwestern Alberta, by M.J. Vonhof and D. Hobson. (2001)

No. 5 2000 survey of the Trumpeter Swan (*Cygnus buccinator*) in Alberta, by M.L. James and A. James. (2001)

No. 6 2000/2001 Brassy Minnow inventory at Musreau Lake and outlet, by T. Ripley. (2001)

No. 7 Colonial nesting waterbird survey in the Northwest Boreal Region – 2000, by M. Hanneman and M. Heckbert. (2001)

No. 8 Burrowing owl trend block survey and monitoring - Brooks and Hanna areas, by D. Scobie and R. Russell. (2000)

No. 9 Survey of the Lake Sturgeon (*Acipenser fulvescens*) fishery on the South Saskatchewan River, Alberta (June-September, 2000), by L.A. Winkel. (2000)

No. 10 An evaluation of grizzly bear-human conflict in the Northwest Boreal Region of Alberta (1991-2000) and potential mitigation, by T. Augustyn. (2001)

No. 11 Harlequin duck monitoring in the Northern East Slopes of Alberta: 1998-2000 preliminary results, by J. Kneteman and A. Hubbs. (2000)

No. 12 Distribution of selected small mammals in Alberta, by L. Engley and M. Norton. (2001)

No. 13 Northern leopard frog reintroduction. Raven River - Year 2 (2000), by K. Kendell. (2001)

No. 14 Cumulative effects of watershed disturbances on fish communities in the Kakwa and Simonette watersheds. The Northern Watershed Project. Study 3 Progress report, by T. Thera and A. Wildeman. (2001)

No. 15 Harlequin duck research in Kananaskis Country in 2000, by C.M. Smith. (2001)

No. 16 Proposed monitoring plan for harlequin ducks in the Bow Region of Alberta, by C.M. Smith. (2001)

No. 17 Distribution and relative abundance of small mammals of the western plains of Alberta as determined from great horned owl pellets, by D. Schowalter. (2001)

No. 18 Western blue flag (*Iris missouriensis*) in Alberta: a census of naturally occurring populations for 2000, by R. Ernst. (2000)

No. 19 Assessing chick survival of sage grouse in Canada, by C.L. Aldridge. (2000)

No. 20 Harlequin duck surveys of the Oldman River Basin in 2000, by D. Paton. (2000)

No. 21 Proposed protocols for inventories of rare plants of the Grassland Natural Region, by C. Wallis. (2001)

No. 22 Utilization of airphoto interpretation to locate prairie rattlesnake (*Crotalus viridis viridis*) hibernacula in the South Saskatchewan River valley, by J. Nicholson and S. Rose. (2001)

No. 23 2000/2001 Progress report on caribou research in west central Alberta, by T. Szkorupa. (2001)

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